Wavelet Domain Watermarking

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Wavelet Transform Domain Embedding Strategies JPEG2000 and Watermarking Possible Application

Wavelet Decomposition

- Successive low-pass / high-pass filtering steps
 - Approximation image (low frequency comp.)
 - detail subbands (sparse high frequency comp.)
 - > Multi–resolution representation



Wavelet Advantages

Robustness [Cox]

- allows to mark significant image components
- ♦ advantages due to transform structure
 - space-frequency localization
 - multi-resolution representation
 - adaptivity [transform structure, filters, HVS]
- efficient implementation, object coding
- ♦ compatibility with JPEG2000 standard

Classification of Embedding Schemes

- decomposition strategy
 - number of levels, adaptivity, packet basis
- ♦ coefficient selection

- approximation image or detail subbands?
- blind / non-blind detection, avail. of original image
- embedding and extraction method
 - additive or quantization strategy
- ♦ HVS modelling
 - implicit or explicit



Additive Watermark Embedding

embedding
$$f(m,n)' = f(m,n) + a \cdot |f(m,n)| \cdot w_i$$

non-blind case extraction $\bar{w}_i = \frac{\bar{f}(m,n) - f(m,n)}{a \cdot |f|}$

blind case

$$d = \frac{1}{M} \cdot \sum_{i=1}^{M} f(m,n)' \cdot w_{i}$$

normalized correlation

$$c = \frac{\sum \bar{w}_i \cdot w_i}{\sqrt{\sum w_i^2} \cdot \sum \bar{w}_i^2}$$

 $c \gg 0$?

detection threshold

detection

$$t = \frac{a}{3 \cdot M} \cdot \sum_{m=1}^{M} \left| f(m,n) \right|$$

 $d \gg t$?

Watermark Detection

trying to detect 1000 random watermarks, watermark #450 was embedded



Quantization Watermark Embedding

embedding function $s(x;m)=Q(x+d(m),\Delta)-d(m)$

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xhost vectormmessaged(.)dither vectorQ(.)quantization function Δ quantization step size

detection function $m = arg_m min(|y - s(y; m)|)$



simple scalar quantization, binary message

JPEG2000 Coding

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JPEG2000 is upcoming ISO standard to supplement JPEG based on Wavelet transform, inherent progressive image transmission many new features, independent processing of code–blocks sophisticated rate/distortion allocation (EBCOT)



Advantages & Constraints

on-the-fly watermark embedding during image coding / decoding - integration with JPEG2000
no extra DWT computation

allows ROI and scalable watermarking

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only local information – 'scope' is one code–block, makes perceptual model computation harder

JPEG2000 Watermark Embedding

code-block

Distinguish code-blocks

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approximation imagedetail subbands

use non-linear scaling for detail subbands $f(x) = sign(x) \cdot |x|^b$



Results: Watermarked Goldhill

capacity 383 bits, PSNR 32.09 dB



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Image Authentication

watermarked and manipulated image



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Tamper Detection

difference image and detected manipulation (after default JPEG compression)



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